EMBEDDED SENSOR NETWORKS FOR WEATHER MONITORING IN UMP PEKAN

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ABSTRACT

This paper presents the implementation of the event-driven Embedded Sensor Network for weather monitoring which is used for environmental monitoring using temperature and humidity sensors.The current situation in Pekan town, especially in UMP Pekan Campus is that the weather is unpredictable and can be very unstable, due to its location. UMP Pekan sits near to the river mouth of Sungai Kuala Pahang and just a few meters away from the South China Sea.Sea wind brings along hot air from the ocean to the land during the day, and brings back cold air from the land to the sea during the night. These phenomenon, together with the huge variance in the humidity parameter, would definitely affect the livelihood of people living in UMP campus. Therefore, this work would like to propose a monitoring mechanism that takes reading samples at constant rates throughout its operation.The aim is to design a system that evaluates samples only when it is triggered by an outside event, which in this rain, hot air,wind, and cold air .The objective of this paper is to develop an embedded sensor network by modifying the programs that run the sensor networks. The embedded sensor network system that will be mechanism developed has variable sampling rates with interfaces to temperature sensors and humidity sensor. The developed system would provide an applicable device that can be used in Universiti Malaysia Pahang as an

organised weather and environmental forecasting system.

ABSTRAK

Projek ini membentangkan pelaksanaan rangkaian pengesan terbenam yang didorong oleh peristiwa untuk pemantauan cuaca yang digunakan untuk pemantauan alam sekitar menggunakan situasi semasa pengesan.Suhu dan kelembapan di Bandar Pekan, terutamanya di Kampus UMP Pekan adalah tidak menentu dan boleh menjadi sangat tidak stabil, kerana kedudukannya. UMP Pekan terletak berhampiran muara sungai Kuala Pahang dan hanya beberapa meter dari angin bayu laut.Laut China Selatan membawa bersama udara panas dari lautan ke darat pada siang hari, dan membawa kembali udara sejuk dari darat itu kepada laut pada waktu malam. Fenomena ini, bersama-sama dengan perubahan besar dalam parameter kelembapan, pasti akan memberi kesan kepada kehidupan orang-orang yang tinggal di kampus UMP. Oleh itu, projek ini ingin mencadangkan satu mekanisme pemantauan yang mengambil masa membaca sampel pada kadar malar seluruh matlamat operasi.Tujuannya adalah untuk merekabentuk satu sistem yang menilai sampel yang hanya apabila ia dicetuskan oleh peristiwa yang di luar, seperti hujan , udara panas, udara angin, dan kelembapan. objektif projek ini adalah untuk membangunkan satu rangkaian pengesan tertanam dengan mengubah suai program yang menjalankan rangkaian sensor. Rangkaian pengesan tertanam ini adalah sistem yang mempunyai kadar pensampelan boleh ubah dengan menggunakan pengesan suhu dan pengesan kelembapan. Sistem yang

dibangunkan akan memberi manfaat yang boleh digunakan di Universiti Malaysia Pahang sebagai sistem ramalan cuaca yang teratur dan sistematik.

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INTRODUCTION

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This paper presents the implementation of the event-driven Embedded Sensor Network for weather monitoring which is used for environmental monitoring using temperature and humidity sensors.The current situation in Pekan town, especially in UMP Pekan Campus is that the weather is unpredictable and can be very unstable, due to its location.

UMP Pekan sits near to the river mouth of Sungai Kuala Pahang and just a few meters away from the South China Sea.Sea wind brings along hot air from the ocean to the land during the day, and brings back cold air from the land to the sea during the night. These phenomenon, together with the huge variance in the humidity parameter, would definitely affect the livelihood of people living in UMP campus.

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1.1 Problem Statement

The current situation in Pekan town, especially in UMP Pekan Campus is that the weather is unpredictable and can be very unstable, due to its location. UMP Pekan sits near to the river mouth of Sungai Kuala Pahang and just a few meters away from the South China Sea. Sea wind brings along hot air from the ocean to the land during the day, and brings back cold air from the land to the sea during the night.

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1.1.1 Research Objective

i. Develop An Embedded Sensor Network By Modifying The Programs That Run The Sensor Networks.

1.1.2 Scope Of Project

i. Determine the area covered by the network
ii. Determine the number of sensor nodes needed to be placed in the network.
iii. Identify the type of sensor used.

1.2 Overview of this Project

This part of introduction provides the work frame of the project. This project consists of five chapters including the introduction.

Chapter 2 holds discussion about the literature review or the past research of this project.

Chapter 3 involves the methodology of the project. The sensor chosen is then applying to embedded sensor network.

Chapter 4 is about the result and discussion about the projects. The result obtain of the display is then discuss on that chapter.

Chapter 5 is about future work and recommendations on how far this project can go further.

1.3 **Summary of chapter.**

In this modern world, most of the systems in the world especially in our country, Malaysia have been developed by experts in their own specific areas for the better quality of life for everyone in this planet. Due to this factor, we can now predict and forecast the weather anywhere on the earth. So with the development of this technology such as the embedded sensor network for weather forecasting will ensure the quality of life will be fine. To achieve this objective, we come out with an idea to build and develop a prediction system that can guarantee a better weather forecasting approach.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, it will aims to review the critical points of current knowledge and or methodological approaches that this project want to develop. This Literature reviews are secondary sources, and as such, do not report any new or original experimental work.

2.1 Embedded Sensor Network ([1] ,[2], [3])

An embedded sensor network is a network of embedded computers placed in the physical world that interacts with the environment. These embedded computers, or sensor nodes, are often physically small, relatively inexpensive computers, each with some set of sensors or actuators. These sensor nodes are deployed in situ, physically placed in the environment near the objects they are sensing. Sensor nodes are networked, allowing them to communicate and cooperate with each other to monitor the environment and (possibly) effect changes to it.

Current sensor networks are usually stationary, although sensors may be attached to moving objects or may even be capable of independent movement. These characteristics: being embedded, being capable of sensing, actuation, and the ability to communicate, define the field of sensor networking and differentiate it from remote sensing, mobile computing with laptop computers, and traditional centralized sensing systems. Although research in sensor networks dates back to the 1990s or earlier, the field exploded around the year 2000 with the availability of relatively inexpensive (sub-$1000) nodes, sensors, and radios. As of 2004, sensor networking is a very active research area with well-established hardware platforms, a growing body of software, and increasing commercial interest. Sensor networks are seeing broader research and commercial deployments in military, scientific, and commercial applications including monitoring of biological habitats, agriculture, and industrial processes.

Sensor networks present challenges in three key areas. First, energy consumption is a common problem in sensor network design. Sensors are often battery operated and placed in remote locations, so any activity drains the sensor battery, and bringing the node closer to death.3 Second, how sensors sense and interact with the physical world is of great interest. Sensor networks focus on collaborative signal processing algorithms to exploit multiple, physically separate views on the environment. Finally, with tens, hundreds, or even thousands of sensor nodes, the network and applications as a whole must be self-configuring.

2.2 Wireless Sensor Network ([4],[5],[6],[7],[8],[9])

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.[4][5]

The WSN is built of nodes from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting.[6][7]

A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes"(demo video) of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.[8][9]

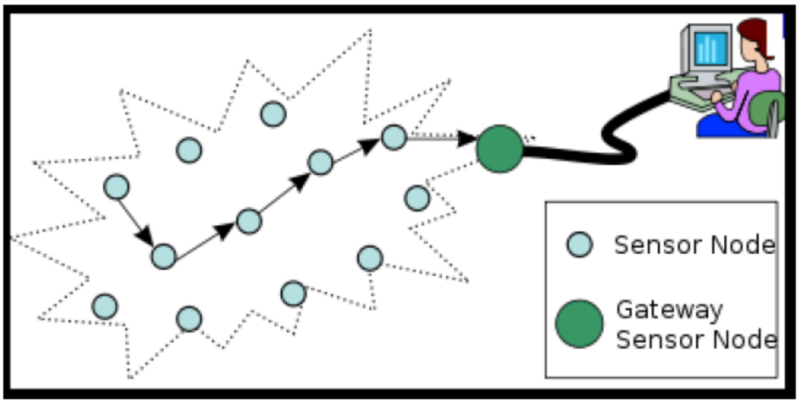

Figure 2.1 :Typical multi-hop wireless sensor network architecture

2.3 Environmental Monitoring [23]

Environmental Monitoring is a typical application for Wireless Sensor Network. The potential benefits of monitoring the environments for example the office environment are to increase the comfort of office workers, employers adhering to health and safety regulations and thus increase the performance, efficiency and productivity of staff [23].

2.3.1 Relative Humidity and Its Effects to Environment

Temperature and humidity can have a significant impact on how alert or tired somebody might feel. This, in turn, can have a dramatic effect on the performance of workers. In hot environments, it is not uncommon for staff to become irritable and less efficient. Humidity can be measured in several ways, but Relative Humidity is the most common. In order to understand relative humidity, it is helpful to first understand absolute humidity. Absolute Humidity is the mass of water vapour divided by the mass of dry air in a volume of air at a given temperature. The hotter the air is, the more water it can contain. Relative humidity is the ratio of the current absolute humidity to the highest possible absolute humidity which depends on the current air temperature. A reading of 100 percent relative humidity means that the air is totally saturated with water vapour and cannot hold any more, creating the possibility of rain. This doesn't mean that the relative humidity must be 100 percent in order for it to rain. It must be 100 percent where the clouds are forming, but the relative humidity near the ground could be much less.

High Humidity Levels increase our susceptibility to high temperature levels as evaporation of body sweat is impeded. Low Humidity Levels has a debilitating effect on our ability to breathe and swallow without discomfort as our mouths and noses can become dry due to the increased level of evaporation in the surrounding environment. Humans are very sensitive to humidity, as the skin relies on the air to get rid of moisture. The process of sweating is your body's attempt to keep cool and maintain its current temperature. If the air is at 100-percent relative humidity, sweat will not evaporate into the air. As a result, we feel much hotter than the actual temperature when the relative humidity is high. If the relative humidity is low, we can feel much cooler than the actual temperature because our sweat evaporates easily, cooling us off. People tend to feel most comfortable at a relative humidity of about 45 percent. Humidifiers and dehumidifiers help to keep indoor humidity at a comfortable level .[23]

2.3.2 Temperature and Its Effects to Environment [23]

An ergonomics study by the Cornell Institute in the US concluded that there were definitive links between the efficiency/productivity levels of workers and the environmental conditions in offices. Although by no means completely representative of all kinds of environments and all type of industry, the research concluded that higher temperatures (in the region of 24-25ºC) resulted in fewer keyboard errors than occurred at temperatures of around 19ºC. In other words, colder workers could mean more errors and therefore higher costs for the employer. In high temperature level, the employee lethargy and tiredness increased as a result of increased body temperature leading to possible efficiency decreases.Meanwhile, low temperature environment will decreases staff efficiency due to cooler body heat and shivering.[23]

2.4 Application of Wireless sensor Network ([10])

The number of potential application for wireless sensor networks is huge. Actuators may also be included in the sensor network, which makes the number of applications that can be developed much higher. In this section, some example applications are given to provide the reader with the better insight about the potentials of wireless sensor networks.[10]

Military Applications:

Wireless sensor networks can be an integral part of military command, control, communications, computers, intelligence, surveillance, reconnaissance and tracking systems. The rapid deployment, self organization and fault tolerance characteristics of the sensor networks make them a very promising sensing technique for military. Since sensor networks are based on the dense deployment of disposable and low cost sensor nodes, destruction of some nodes by hostile actions does not affect a military operation as mush as the destruction of a traditional sensor. Some of the military applications are monitoring friendly forces, equipment and ammunition, battlefield surveillance, reconnaissance of opposing forces and terrain, targeting, battle damage assessment, and nuclear, biological and chemical attack detection and reconnaissance.[10]

Environmental Application:

Some environmental applications of the sensor networks include tracking the movements of species, i.e., habitat monitoring, monitoring environmental conditions that affect crops and livestock, irrigation, macro instruments for large-scale Earth monitoring and planetary exploration, and chemical/ biological detection.

Commercial Application:

The sensor networks are also applied in many commercial applications. Some of them are building virtual keyboards, managing inventory control, monitoring product quality, constructing smart office spaces and environmental control in office buildings.

2.5 Challenges in WSN([20],[21],[22])

Once WSN is deployed, normally sensor nodes are leave unattended. This leaves the sensor nodes and a dependent power source which will dies out over time. So it is important for sensor nodes to have a very reliable power source to prolong its network lifetime. Imagine if the nodes are place in the enemy line for battlefield surveillance and its power unit can only power up the sensor nodes for a few days, it definitely would be an unreliable system. Energy management has been a major focus on development of WSN for the past few years and alternative energy source has been introduced such as solar panel and piezoelectric transducer to power the sensor nodes . But this alternative energy source works in certain condition only. For example, solar panel needs to have sunlight to convert light to useful energy and piezoelectric need to have vibration. More techniques and protocols involving energy management will be later discussed in the next section.

On certain applications, data collected by sensor nodes are highly sensitive especially in military applications and other government applications. This has brought another issue in WSN which is security. WSN is a special network which has many constraints compared to a standard computer network. Due to these constraints, it is not possible to directly employ the existing security approaches to the area of WSN . The main aspects in security are data confidentiality which to avoid omission of data leaks to neighbouring networks, data authentication for verification of sender and receiver, data integrity to ensure data are not altered during transmission and lastly data freshness is to guarantee data is recent while allowing for delay estimation.

2.6 Universal asynchronous receiver/transmitter (UART) ([4],[5],[6],[7],[13])

A universal asynchronous receiver/transmitter is a type of "asynchronous receiver/transmitter", a piece of computer hardware that translates data between parallel and serial forms. UARTs are commonly used in conjunction with communication standards such as EIA RS-232, RS-422 or RS-485. The universal designation indicates that the data format and transmission speeds are configurable and that the actual electric signalling levels and methods (such as differential signalling etc.) typically are handled by a special driver circuit external to the UART.

A UART is usually an individual (or part of an) integrated circuit used for serial communications over a computer or peripheral device serial port. UARTs are now commonly included in microcontrollers. A dual UART, or DUART, combines two UARTs into a single chip. Many modern ICs now come with a UART that can also communicate synchronously; these devices are called USARTs (universal synchronous/asynchronous receiver/transmitter).

A UART usually contains the following components:

i. a clock generator, usually a multiple of the bit rate to allow sampling in the middle of a bit period.

ii. input and output shift registers

iii. transmit/receive control

iv. read/write control logic

v. transmit/receive buffers (optional)

vi. parallel data bus buffer (optional)

vii. First-in, first-out (FIFO) buffer memory (optional)

2.7 C language Programming ([14])

C programming language as it applies to embedded microcontroller applications. This programming needed programmer to declaring variables and constant do loops, testing the logic analyser. In c programming there are several types of loops. Next, the important part is software to interface with PIC. Software used is C programming. C compiler is software to write, simulate and burn the program into PIC.

To ensure written programming worked or not, it can combine with software Proteus. From this software, program can be simulating with circuit.[14]

2.8 ZigBee ([15],[16],[17])

Article [15]

Fred Eady is specially described about XBee. In this article, all the information about XBee is stated. The family of XBee, the pin connection, the way XBee can be interface with other product. In this article also explain the suitable microcontroller that can be interface with XBee.[15]

Article [16]

In this article, Fabrice André is specially described about XBee. In this article, it contains the pin description, the software that is used to setup the XBee, the explanation of internal of the XBee, and the comparisons between other wireless devices. In this article, the author explains more information about the software of the XBee. [16]

Article [17]

Fabrice André is specially described about the interfacing of XBee with computer. In this article, it explains more to the hardware of XBee. It explains the limitation of current that can flow in the XBee module. [17]

2.8.1 ZigBee Protocol[24]

ZigBee is a protocol that uses the 802.15.4 standard as a baseline and adds additional routing and networking functionality. The ZigBee protocol was developed by the ZigBee Alliance. The ZigBee Alliance is a group of companies that worked in cooperation to develop a network protocol that can be used in a variety of commercial and industrial low data rate applications. ZigBee is a type of LR-WPAN technology and is built upon the lower layers of the IEEE 802.15.4 LR-WPAN standard. While the 802.15.4 standard defines the lower-level Physical (PHY) and Media Access Control (MAC) layers, the ZigBee standard defines the higher-level Network and Application layers as well as the security services .[24]

2.8.2 Technology Overview

The 802.15.4 is a standard for wireless communication put out by the Institute for Electrical and Electronics Engineers (IEEE). The IEEE is a technical professional association that has put out numerous standards to promote growth and interoperability of existing and emerging technologies. The 802.15.4 standard allows for communication in a point-to-point or a point-to-multipoint configuration. Mesh networking is used in applications where the range between two points may be beyond the range of the two radios located at those points, but intermediate radios are in place that could forward on any messages to and from the desired radios. For example, in the figure below suppose we wanted to transmit data from point A to point B, but the distance was too great between the points. The message could be transmitted through point C and a few other radios to reach the destination.